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RESEARCH ARTICLE

DIALECTICS OF COLLECTIVE MINDING: CONTRADICTORY APPROPRIATIONS OF INFORMATION TECHNOLOGY IN A HIGH-RISK PROJECT

Jessica Luo Carlo
Department of Advertising, Public Relations, and Retailing, Michigan State University,
East Lansing, MI 48824-1212 U.S.A. {carloj@msu.edu}

Kalle Lyytinen and Richard J. Boland, Jr.
Department of Information Systems, Weatherhead School of Management, Case Western Reserve University,
Cleveland, OH 44106 U.S.A. {kalle@case.edu} {boland@case.edu}

Appendix A

Capabilities of CATIA

Computer-aided three-dimensional interactive application (CATIA) was originally developed by Dassault Systems to design and manufacture complex geometries for jet fighters. Lately, it has been adopted as a multi-platform 3-D product life cycle management solution and is used widely as a design platform in several industries, including the automobile, aerospace, ship-building, and consumer electronics industries. It supports multiple phases of product development, including design (i.e., computer-aided design—CAD), analysis (computer-aided engineering—CAE), and manufacturing (computer-aided manufacturing—CAM). It includes, among others, the following capabilities.

3-D Modeling

CATIA uses three methods to create 3-D objects:

(1) *Wireframe modeling* uses parametric/mathematical data to produce visual presentations of physical objects. For instance, CATIA can draw a circle by specifying the location of the center in space and the length of its diameter, or specify the edge of an object by connecting its constituent vertices using straight lines or curves. As shown in Figure A1, wireframe modeling allows visualization of the underlying design "structure" of a 3-D model. The wireframe format is widely used in programming tool paths for direct numerical control (DNC) machine tools.

(2) *Surface modeling* describes freeform surfaces of a 3-D object. Since freeform surfaces do not have rigid radial dimensions, CATIA describes the shape using non-uniform rational basis splines (NURBS) and Bézier splines. As shown in Figure A2, the freeform surfaces are defined by manipulating the surface control points, degree, and number of segments of curves. As a result, free forms, such as building exterior skins, can be reproduced with extreme mathematical accuracy.

(3) *Solid modeling* conveys information about the solid attributes of a 3-D object (e.g., mass, volume, density, etc). Instead of storing product information in separate text attachments, CATIA helps encapsulate rich and discrete design product data directly with 3-D objects. As shown in Figure A3, 3-D objects in CATIA can thus mirror the solid parts of "real-world objects"(Yap et al. 2003).

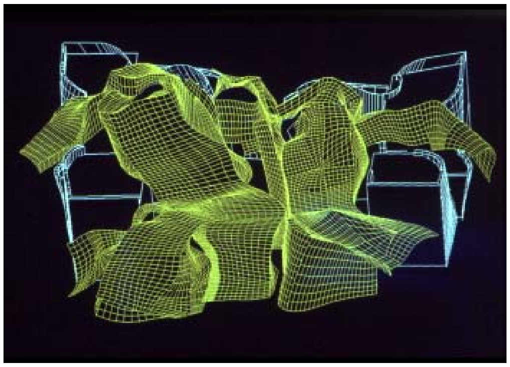

Figure A1. 3-D Wireframe Diagram

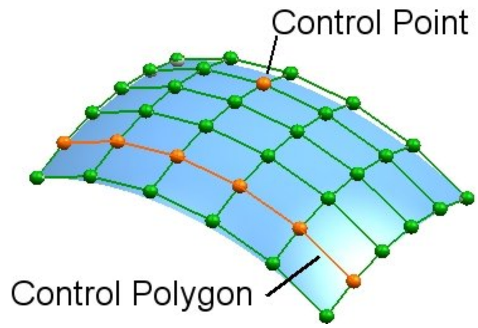

Figure A2. 3-D Surface Model

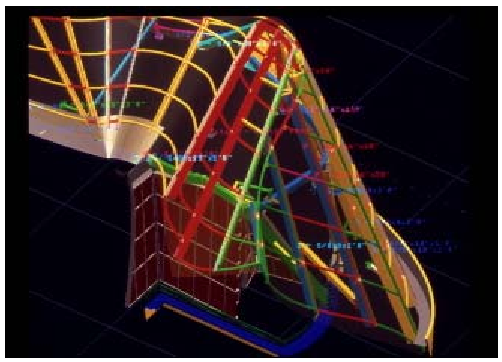

Figure A3. 3-D Solid Model

3-D Visualization

CATIA generates full visualizations of designs in actual scale from any angle, including “fly through” capability. This allows multiple aspects of a design to be displayed and explored interactively (Baba and Nobeoka 1998). 3-D objects are visualized using both graphic representations and parametric/mathematical representations (Yap et al. 2003). Such full 3-D visualization is the outcome of using mathematically accurate 3-D modeling. By slicing the model from different angles and at different levels, the user can observe how various elements relate to each other and thus grasp their overall relationships.

xyz Coordination

CATIA controls the dimensions of 3-D objects by using an absolute three-dimensional xyz Euclidian coordinate system. This helps accurately triangulate the geometric position of each object in the design space. Each measurement related to any object is carried out vis-a-vis a pre-established absolute starting point ($x = 0, y = 0, z = 0$). As a result, each produced coordinate conveys absolute and accurate spatial information relative to the full-scale digital model.

3-D Object Properties

As mentioned, instead of storing product information in separate documents, CATIA objects allow encapsulation of rich design and product information. Any object can be assigned with its material attributes, such as measurements, shape, color, and a set of behaviors. CATIA also includes a parametric catalog that can be accessed through design object tables, which can generate customizable bills of materials (BOM) lists. The parametric information extracted from CATIA can also be used in programming tool paths for computer numerical control (CNC) tools for tailored manufacturing.

Analysis and Simulation

By using parametric equations and interference checks during wireframe modeling, a minute change in one component can be propagated to related changes in the adjacent components. As a result, CATIA performs design change analysis easily and accurately. With rich product information encapsulated into 3-D objects, CATIA can also deploy robust finite-element analysis (FEA) techniques to simulate the structural strength and performance of any structural model. For instance, the loading variables (e.g., pressure, volume) can be imported from external files (e.g., files containing a grid of xyz coordinates and load values) and then mapped to the geometry to carry out detailed analyses, including collision detection, thermal and mechanical stress analysis, tolerance analysis, and kinematic analysis (Baba and Nobeoka 1998).

Data Extraction and Transfer

CATIA operates with shared and centralized databases and conforms to product data standards, such as STEP (an ISO standard for CAD product files) or different 3-D representation standards. Therefore, design data can be transferred across multiple systems/platforms (e.g., Rhino, Pro/ENGINEER, SolidWorks, 2-D AutoCAD, 3-D AutoCAD). Such seamless data transfer helps coordinate design/construction activities within and across organizational boundaries, since different design communities often use different tools with different representations (Baba and Nobeoka 1998; Christman 2006; Yap et al. 2003). For example, Gehry Partners used multiple IT tools that could transfer files with CATIA: (1) 2-D AutoCAD or 3-D AutoCAD as substitutes for CATIA representation for some contractors or regulators; (2) Rhino for early design sketching and analysis; and (3) Excel spreadsheets for data storage on design points and management of construction budgets.

Communication and Coordination

CATIA can be integrated with generic communication and coordination tools, such as (1) a website to share CATIA drawings among contractors, (2) e-mail for sharing design documents and change requests or to negotiate about them, and (3) video conferences for communication and project coordination (Baba and Nobeoka 1998).

References

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